Háskóli Íslands
Raunvísindadeild
Eðlisfræði

Vor 2021

Frumeinda- og ljósfræði

Dæmablað 4

Skilafrestur 11. Febrúar 2021 kl. 15:00

1. **Stern-Gerlach magnet** (10)

   Determine the field gradient of a 50 cm long Stern-Gerlach magnet that would produce a 1 mm separation at the end of the magnet between the two components of a beam of silver atoms emitted with typical kinetic energy from a 960°C oven. The magnetic dipole moment of silver is due to a single $l = 0$ electron, just as for hydrogen.

2. **Hydrogen atom in magnetic field** (20)

   If a hydrogen atom is placed in a magnetic field which is very strong compared to its internal field, its orbital and spin magnetic dipole moments precess independently about the external field, and its energy depends on the quantum numbers m_l and m_s which specify their components along the external field direction.

   (a) Evaluate the splitting of the energy levels according to the values of m_l and m_s.

   (b) Draw the pattern of split levels originating from the $n = 2$ level, enumerating the quantum numbers of each component of the pattern.

   (c) Calculate the strength of the external magnetic field that would produce an energy difference between the most widely separated $n = 2$ levels which equals the difference between the energies of the $n = 1$ and $n = 2$ levels in the absence of the field.

3. **Energy level scheme for helium** (10)

   Discuss (qualitatively) the energy level scheme for helium if (a) electrons were identical bosons, and (b) if electrons were distinguishable particles (but with the same mass and charge). Pretend these "electrons" still have spin 1/2, so the spin configurations are the singlet and the triplet.

4. **Angle between L and S** (10)

   Consider the states in which $l = 4$ and $s = 1/2$. For the state with the largest possible j and largest possible m_j, calculate

   (a) the angle between **L** and **S**

   (b) the angle between μ_l and μ_s

   (c) the angle between **J** and the $+z$ axis.